

independent claim 1. However, by preliminary amendment, Applicants had amended each of claims 2, 4, and 6 to depend from claim 9. In response to the Non-final Office Action of 26 March 2002, Applicants amended claim 1 to include the subject matter of claim 5, canceled claim 9 and inadvertently failed to change the dependencies of claims 2, 4, and 6. When Applicants tried to rectify this with respect to claims 4 and 6 in response to the Final Office Action of 26 August 2002, the amendment was not entered.

Applicants are submitting this amendment with the RCE so as to obtain a proper set of claims for further prosecution. Two attachments are enclosed. Attachment 1 is a version of markings to show changes made, and Attachment 2 is a clean set of claims as amended.

Applicants are further including the substance of Applicants position regarding the allowability of the remaining claims.

Summary of invention

MEMS devices include fragile structures such as thin flexible membranes or rigid moving parts. The fragile structures can easily be damaged mechanically or by exposure to moisture. Protection of the fragile structures has posed a problem both for use of MEMS devices and for multichip module (MCM) packaging of MEMS devices.

Most MEMS devices are packaged in an "unreleased" state and require a "release" etch prior to operational use. The release process often includes removing selected materials to create three-dimensional structures and, in some cases, to allow physical movement. Released MEMS devices are typically very fragile and require special handling. MCM packaging of unreleased MEMS devices requires that the package materials be compatible with the MEMS release procedures, and protective enclosures typically are not provided as part of the package.

In one aspect of Applicants' invention, as recited in claim 1, a method for packaging a microelectromechanical system (MEMS) device 20 comprises: using a partially-cured adhesive 12 to attach a release sheet 14 to a MEMS package flexible layer 10 (FIG. 1 and paragraph 12); providing a cavity 16 having a smooth surface perimeter and extending through the release sheet and at least partially through the MEMS package flexible layer (FIGs. 2-3 and paragraphs 12 and 16); removing the release sheet (FIG. 5 and paragraph 12); and attaching the MEMS device to the MEMS package flexible layer with a MEMS structure 22 of the MEMS device being positioned within the cavity (FIG. 6 and paragraph 12).

In a related aspect of Applicants' invention, as recited in claim 16, a method for packaging a microelectromechanical system (MEMS) device 20 comprises: coating an MEMS package flexible layer 10 with an adhesive 16 (paragraph 14); partially curing the adhesive (paragraph 14); using the adhesive to attach a release sheet 14 to the MEMS package flexible layer (FIG. 1 and paragraph 12); providing a cavity 16 having a smooth surface perimeter and extending through the release sheet, the adhesive, and at least partially through the MEMS package flexible layer (FIGs. 2-3 and paragraphs 12 and 16);

removing the release sheet (FIG. 5 and paragraph 12); using the adhesive to attach the MEMS device to the MEMS package flexible layer with a MEMS structure 22 of the MEMS device being positioned within the cavity (FIG. 6 and paragraph 19); providing MEMS vias 26 through the MEMS package flexible layer extending to connection pads 24 of the MEMS device (FIG. 7 and paragraphs 20-21); and applying a MEMS pattern of electrical conductors 28 on the MEMS package flexible layer and extending through the MEMS vias to the connection pads (FIG. 7 and paragraphs 20-21).

In another aspect of Applicants' invention, as recited in claim 7, a method for packaging a microelectromechanical system (MEMS) device 20 comprises: using a partially-cured adhesive 12 to attach a release sheet 14 to a MEMS package flexible layer 10 (FIG. 1 and paragraph 12); providing a cavity 16 extending through the release sheet and partially through the MEMS package flexible layer (FIG. 2 and paragraph 12); providing a protective coating 18 in the cavity (FIGs. 4-5 and paragraphs 17-18); then removing the release sheet; and attaching the MEMS device to the MEMS package flexible layer with a MEMS structure 22 of the MEMS device being positioned within the cavity (FIG. 6 and paragraph 19).

Grouping of claims

Claim 1 (independent), claims 2-4 and 6, claim 16 (independent), and claim 19 stand or fall together.

Claim 7 (independent) and claim 8 stand or fall together.

C. Argument

Explanation of why claims 1-4, 6, 16, and 19 and claims 7-8 are separately patentable from each other

Claims 1-4, 6, 16, and 19 each include a recitation of a cavity having a smooth surface perimeter. This recitation is not present in claims 7-8 and is useful for the reasons stated in paragraph 16, lines 3-11, of Applicants' Specification:

"Smooth-surfaced perimeter" is meant to encompass any perimeter without sharp edges (such as 90 degree corners in square or rectangular perimeters). Examples of smooth-surfaced perimeters include ovals, circles, rounded rectangles as shown in FIG. 3, or other straight line perimeters having rounded corners or corners of greater than 120 degrees, for example. Smooth-surfaced perimeters are useful for evenly distributing any excess adhesive that is close to the surface of MEMS structure 22. Harsh-surfaced perimeters such as 90 degree corners create the potential for localized stress and excess flow of adhesive (and thus the potential for interference with MEMS structure 22).

Claims 7-8 each recite "providing a protective coating in the cavity" and "then removing the release sheet." This recitation is not present in independent claim 1 or 16. As described in paragraph 17, the process of claim 7 results in protective coating remaining only in the cavity. Thus, the order of events permits the protective coating to be easily blanket-sputtered and easily removed so as to remain in the desired location.

Brief Characterization of the Prior Art Relied on in the Final Rejection

Gorowitz et al., US Patent No. 5,757,072 (hereinafter Gorowitz)

Gorowitz appears to relate to deposition of a protective cap 16 over an air bridge structure of an integrated circuit chip. In the context of FIGs. 1 and 2, Gorowitz column 6, lines 60-66, recites:

Protective cap 16 is a protective "shield" structure comprising a cover-portion 16t having a top surface 16e and a bottom surface 16d, and a peripheral leg-portion 16l extending from the cover-portion bottom surface 16d to component surface 12b. Cover-portion 16t and leg-portion 16l cooperate to define a "U shaped" recess 16r.

The "U shape" appears to relate to the walls (defined by surface 16b of leg-portion 16l) and roof (defined by surface 16a of cover-portion 16t) of the protective cap.

Noddin, US Patent No. 5,731,047

Noddin appears to relate to a method of forming a blind via in a laminated substrate using a plurality of laser pulses (abstract) and was cited in the office action in regards to column 31, lines 10-15:

The web was dried at 165 °C. for 1 min. under tension to afford a flexible composite. The partially-cured adhesive composite thus produced comprised of 57 weight percent TiO₂, 13 weight percent PTFE and 30 weight percent epoxy adhesive. Several plies of the adhesive sheet were laid up between copper foil and pressed at 600 psi in a vacuum-assisted hydraulic press at temperature of 225 °C. for 90 min.

Saia et al., US Patent No. 6,150,719 (hereinafter Saia)

Saia appears to relate to an amorphous hydrogenated carbon hermetic structure overlying a polymer film structure to form a corrosion resistant structure (abstract).

Discussion of the issues presented by the final rejectionWhether claims 1-4, 6 and 16 are unpatentable under 35 USC 103(a) on Gorowitz in view of Noddin

Independent Claim 1 (from which claims 2-4 and 6 depend) and independent claim 16 define allowable subject matter over Gorowitz and Noddin.

Independent claim 1 recites: "using a partially-cured adhesive to attach a release sheet to a MEMS package flexible layer" and "providing a cavity having a smooth surface perimeter and extending through the release sheet and at least partially through the MEMS package flexible layer." Independent claim 16 recites: "partially curing the adhesive," "using the adhesive to attach a release sheet to the MEMS package flexible layer," and "providing a cavity having a smooth surface perimeter and extending through the release sheet, the adhesive, and at least partially through the MEMS package flexible layer."

Applicants respectfully submit that, even if one were to assume that the teachings or suggestions of Gorowitz and Noddin were to be combined, no combination of the references teaches

or suggests these claim recitations.

In response to paper number 8, Applicants respectfully traversed the Office Action statement on page 2, section 2, paragraph 4 alleging that Gorowitz discloses "providing a cavity 16r having a smooth surface perimeter (column 6, lines 65-66)." Applicants likewise traversed the Office Action statement on page 4, Response to Arguments, paragraph 3 alleging "Gorowitz et al. disclose the cavity 16r is a 'U shaped' (fig. 2, column 6, lines 65-66). Therefore, Gorowitz et al. disclose the cavity has a smooth surface perimeter."

Applicants pointed out that, in paragraph 16, lines 3-11, of Applicants' Specification:

"Smooth-surfaced perimeter" is meant to encompass any perimeter without sharp edges (such as 90 degree corners in square or rectangular perimeters). Examples of smooth-surfaced perimeters include ovals, circles, rounded rectangles as shown in FIG. 3, or other straight line perimeters having rounded corners or corners of greater than 120 degrees, for example. Smooth-surfaced perimeters are useful for evenly distributing any excess adhesive that is close to the surface of MEMS structure 22. Harsh-surfaced perimeters such as 90 degree corners create the potential for localized stress and excess flow of adhesive (and thus the potential for interference with MEMS structure 22).

Applicants further pointed out that, in the context of FIGs. 1 and 2, Gorowitz column 6, lines 60-66 recite:

Protective cap 16 is a protective "shield" structure comprising a cover-portion 16t having a top surface 16e and a bottom surface 16d, and a peripheral leg-portion 16l extending from the cover-portion bottom surface 16d to component surface 12b. Cover-portion 16t and leg-portion 16l cooperate to define a "U shaped" recess 16r.

Applicants continue to assert that the "U shape" is not described in a manner that relates to the perimeter as described in Applicants' Specification (paragraph 16) and shown in FIG. 3. Instead the "U shape" appears to relate to the walls (defined by surface 16b of leg-portion 16l) and roof (defined by surface 16a of cover-portion 16t) of the protective cap. Noddin does not overcome the above absence of the teaching, suggestion, or disclosure of a smooth surface perimeter in Gorowitz.

With respect to claim 1 and 16, the Advisory Action stated:

Continuation of 5. does NOT place the application in condition for allowance. ... Gorowitz et al. disclose the cavity 16r is a "U shaped" (fig. 2, column 6, lines 65-66). Therefore Gorowitz et al. disclose the cavity has a smooth surface perimeter. The limitation of the smooth surfaced perimeters include oval, circles, etc... is not disclosed in the claimed invention.

Applicants respectfully disagree with the second sentence of the above paragraph do not understand the last sentence of the above paragraph. Applicants used the word "smooth-surfaced perimeter" in the claims and carefully defined it in the specification. The U shape of Gorowitz relates to the three dimensional profile of the walls and not to the perimeter of the cavity which will be coming into contact with the adhesive in the manner defined by Applicants in the specification. Because this recitation is completely missing from both references, Applicants respectfully submit that a prima facie case has not been made for the rejections of independent claims 1 and 16.

Whether claims 7-8 and 19 are unpatentable under 35 USC 103(a) on Gorowitz and Noddin and further in view of Saia

Independent Claims 7 defines allowable subject matter over Gorowitz, Noddin, and Saia. Claim 8 depends from claim 7. Claim 19 depends from the above discussed claim 16 and stands or falls therewith.

Independent claim 7 recites: "providing a protective coating in the cavity" and "then removing the release sheet."

Applicants respectfully submit that, even if one were to assume that the teachings or suggestions of Gorowitz, Noddin, and Saia were to be combined, no combination of the references teaches or suggests these claim recitations.

In response to paper number 8, Applicants continued to respectfully traverse the Office Action statement on pages 4 and 5 that "it would have been obvious ... to modify the device of Gorowitz et al. with a protective coating for the polymer film, as shown by Saia et al." Applicants additionally noted that there appeared to be a typing error in the Office Action on page 5, the second full paragraph which should start with "Saia discloses ..." rather than be interpretable as a continuation of the discussion of Gorowitz in the first full paragraph.

Applicants interpreted paper number 8 as stating that (1) Gorowitz and Noddin do not disclose providing a protective coating in the cavity; (2) Saia describes a DLC film forming a hermetic seal over a polymer film structure to protect the polymer film; and (3) it would have been obvious to provide the protective coating in the cavity. For support of point 3, the paper number 8 further referred to an antireflective coating of a non-relied upon reference (Hays et al., US Patent No. 6,252,229) as showing a reflective coating in a cavity. Applicants pointed out that Hays appears to relate to pressure seals between two semiconductor type substrates encasing a structure such as a microbolometer (array of small radiation detectors), that the anti-reflective coating appeared to be suggested for "permit[ting] transmission of the radiation to be detected" (see column 7, lines 22-27), that there is no mention in Hays of a protective coating, and that Applicants fail to see how Hays is pertinent.

More specifically, Applicants indicated their failure to understand how point 3 follows from points 1 and 2. In Saia, the coating is an **external** (on an outer polymer surface) coating over a polymer film structure to protect underlying metallization (Saia, column 4, lines 30-40). The motivation to apply this description to an **internal** (on an inner surface facing a chip) coating is not clear to the Applicants.

Furthermore, Applicants indicate that the specific motivation for applying the coating **prior** to removing the release sheet is not shown in the Office Action (paper number 8). As described in paragraphs 17-18 of the Specification, this ordering is useful for permitting blanket application of the protective coating which will then only remain in the cavities after removal of the release layer. This feature would be difficult to realize with the Gorowitz embodiment. Page 3 of the Office Action characterizes element 32 as a Kapton polyimide film in an attempt to fit it into Applicants' characterization

of a "release sheet." Gorowitz however, calls element 32 a "hard mask layer" (column 9, line 3) with examples being metals which typically require etching for removal (see column 9, lines 5-15).

With respect to claim 7, the Advisory Action stated:

Continuation of 5. does NOT place the application in condition for allowance because: ... Gorowitz et al. disclose the cavity 16r and Saia et al. disclose the DLC forms a hermetic seal over the polymer film structure (abstract). Therefore, it would have been obvious to one having ordinary skill in the art to provide a protective coating in the cavity of Gorowitz et al. to form a hermetic sea, as shown by Saia et al.

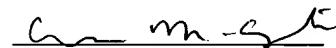
Applicants continue to respectfully submit that there is no suggestion to combine the cited references in this manner. The suggestion to combine requirement is a safeguard against the use of hindsight combinations to negate patentability. The mere fact that the prior art may be modified in the manner suggested by the Examiner does not make the modification obvious unless the prior art suggested the desirability of the modification. In re Fritch, 972 F.2d 1260, 1266, 23 USPQ2d 1780, 1783-84 (Fed. Cir. 1982). The reasons one of ordinary skill in the art would have been motivated to select the references and combine them must be identified specifically. In re Rouffet, 149 F.3d 1350, 1359, 47 USPQ2d 1453, 1459 (Fed. Cir. 1998).

At a minimum Applicants submit that a prima facie case has not been made for the rejection of independent claim 7 due to the lack of a showing of a modification relating to the order of applying the coating prior to removing the release sheet.

Summary

Accordingly, Applicants respectfully submit that the claimed invention defines allowable subject matter over the applied art.

Respectfully submitted,



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Attachment 1: Version with markings to show changes made

2 (twice amended). The method of claim [9] 1 further comprising providing MEMS vias through the MEMS package flexible layer and the cover extending to connection pads of the MEMS device and applying a MEMS pattern of electrical conductors over the MEMS package flexible layer and the cover and extending through the MEMS vias to the connection pads.

4 (twice amended). The method of claim [9] 3 wherein attaching the MEMS device comprises using the adhesive.

6 (twice amended). The method of claim [9,] 1 wherein the adhesive comprises a mixture of photodielectric and epoxy materials.